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The spin of the nucleon in its rest system

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Abstract

The spin dependent structure functions, g_{1p} of the proton and g_{1n} of the neutron, calculated in the nucleon rest frame using a relativistic quark model wave function,are compared with recent experiments.

A number of measurements have been made recently of the spin dependent structure functions, g_{1p} of the proton[1, 2, 3] and g_{1n} of the neutron.[4, 5] These measurements have led to some difficulty of interpretation when used in QCD sum rules, which have seemed to imply a relatively large polarization of the quark sea (including the strange sea) and gluon distributions, and a relatively small contribution of quarks to the proton spin.

An alternative model for calculating nucleon structure has been to calculate deep inelastic scattering cross sections in the target rest frame, using an appropriate relativistic quark model wave function. The structure functions can then be determined from the cross section. Details of this model are contained in Refs. [6, 7, 8, 9]. At its present stage of development this model does not include quark pair production by the incident virtual photon, which would correspond to the quark sea that is introduced in the parton model. Because of this the fit obtained to the spin independent stucture functions observed in unpolarized scattering is only good for x>0.3, as is common in valence quark models. The parameters of the input quark wave function are determined by a direct fit to the low Q^2 ($4< Q^2 < 20$ GeV^2), large x (x>0.3) electron-proton and electron-deuteron SLAC cross section data summarized by Whitlow.[10] This then permits a direct prediction of the spin dependent structure functions, g_1 and g_2, of the proton and neutron. Somewhat surprisingly, the prediction for g_1 agrees with experiment for x below 0.3 as well

as for the higher x. We take this as an indication that the mechanisms so far left out of the rest frame model do not contribute to the polarization. This is in contrast to the large polarization of the non-quark effects in the usual parton model interpretation.

We present the comparision with experiment in Figs. $1-5$. In all cases, the rest frame structure function has been calculated for the value of Q^2 appropriate to each experimental point. Figure 1 shows the original EMC[1] data for g_{1p} along with the rest frame model prediction. Figure 2 shows the SMC[2] g_{1p} data with the rest frame model prediction. The solid triangle on the x axis represents the x below which Q^2 becomes less than 4 GeV^2, and coherent scattering becomes important. The rest frame model is not expected to apply at these low $Q^2 < 4$ GeV^2.

Figure 3 shows the g_{1p} data of the SLAC E143 experiment[3], along with the rest frame model prediction. The points for x<0.14, indicated by the solid triangle on the x axis, have $Q^2 < 4$ GeV^2. At the relatively low values of Q^2 in this experiment, all points for x>0.47, indicated by the open triangle on the x axis, have W (the final state invariant mass) less than 3 GeV. The jump in the SLAC g_{1p} in this x region may be due to direct resonance production polarization, effective at these low values of W and Q^2. There is only one SMC point from Fig. 2 in this x range, represented in Fig. 3 by the open circle at x=0.48. This SMC point has W=8 GeV and Q^2=58 GeV^2. By contrast, the E143 point at x=0.53 has W=2.8 GeV and Q^2=7.6 GeV^2. It will be interesting to see if future data in this x range comes down to the SMC level as Q^2 and W are increased.

The E142 measurement[4] of the neutron spin dependent structure function g_{1n} at SLAC is shown in Fig. 4, along with the rest frame model prediction. However, all of the E142 data has either W<3 GeV or $Q^2 < 4$ GeV^2. Figure 5 shows the SMC data[5] for g_{1d} of the deuteron normalized to represent the average of g_{1p} and g_{1n}, along with the rest frame model prediction for this. The points for x below the solid triangle on the x axis have $Q^2 < 4$ GeV^2.

References

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Fig. 1. g_{1p} by EMC

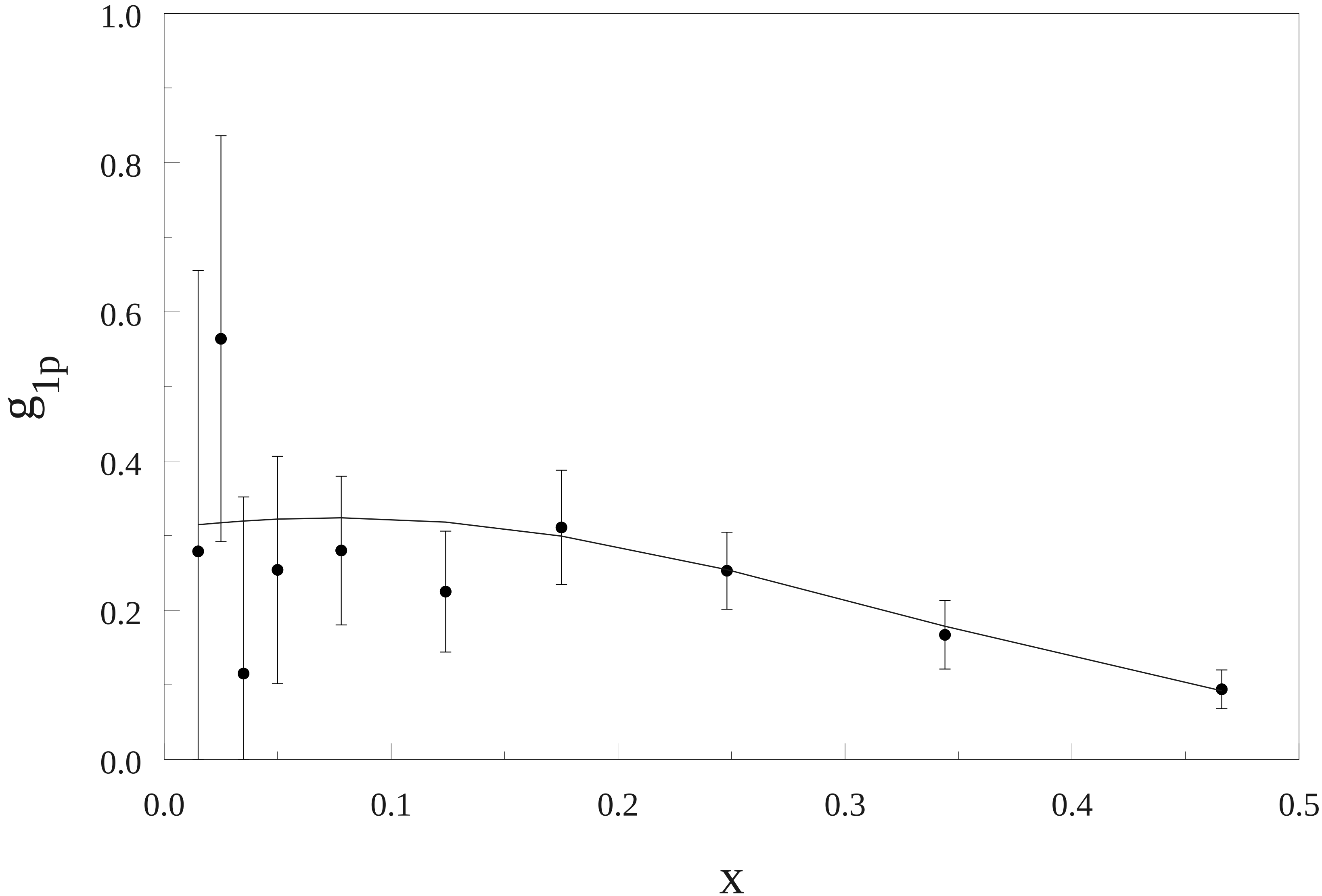

Fig. 2. g_{1p} by SMC

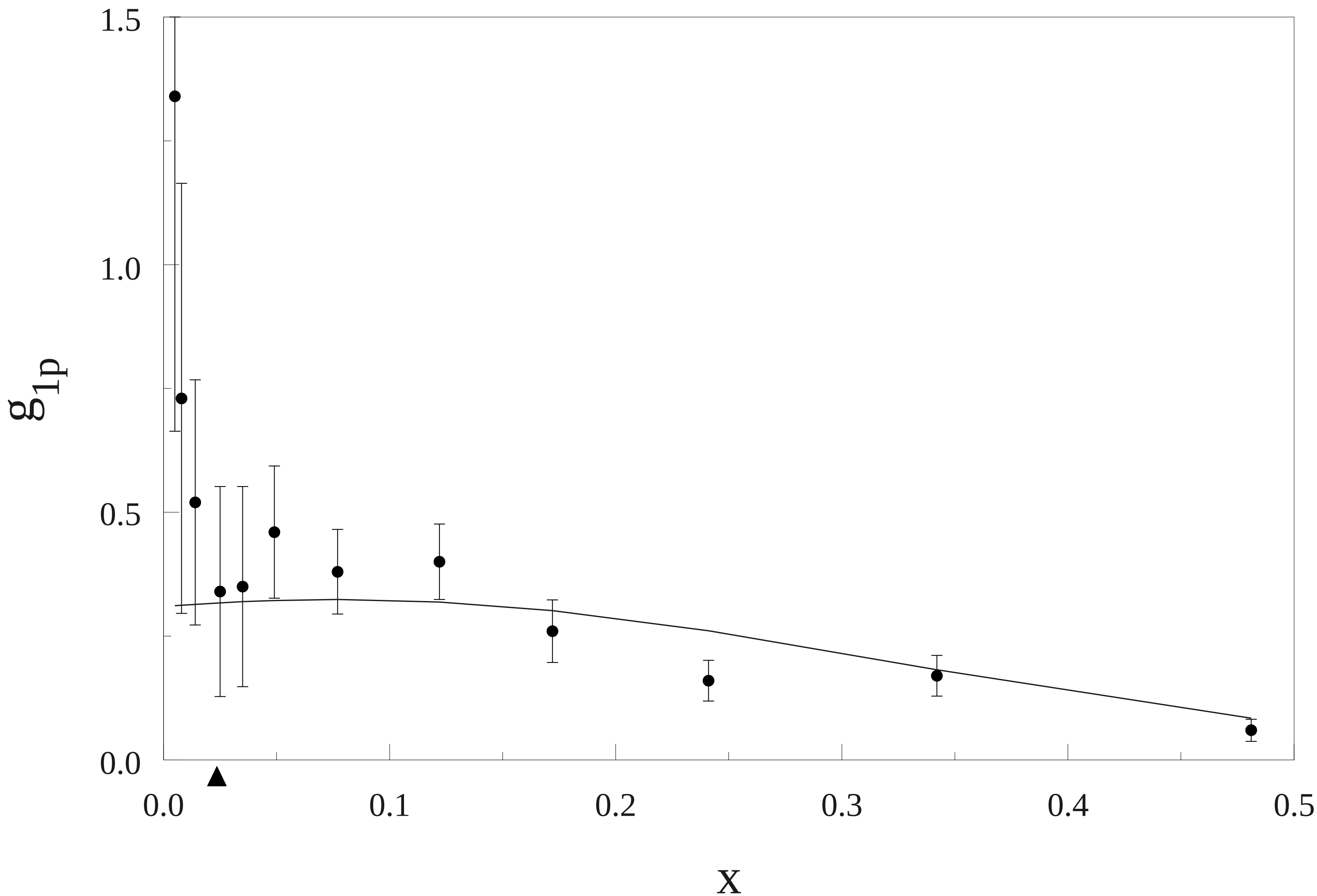

Fig. 3. g_{1p} by SLAC E143

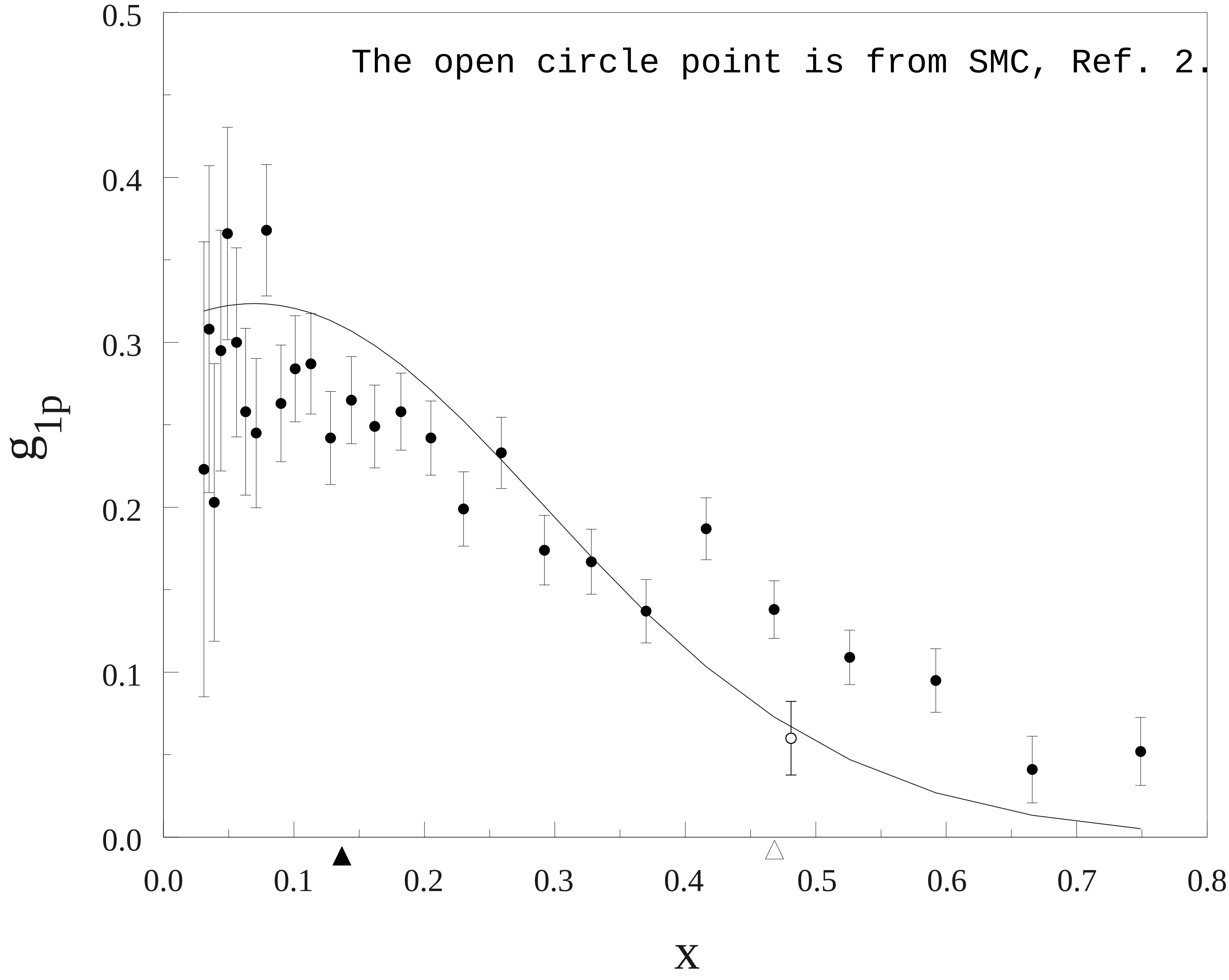

Fig. 4. g_{1n} by E142

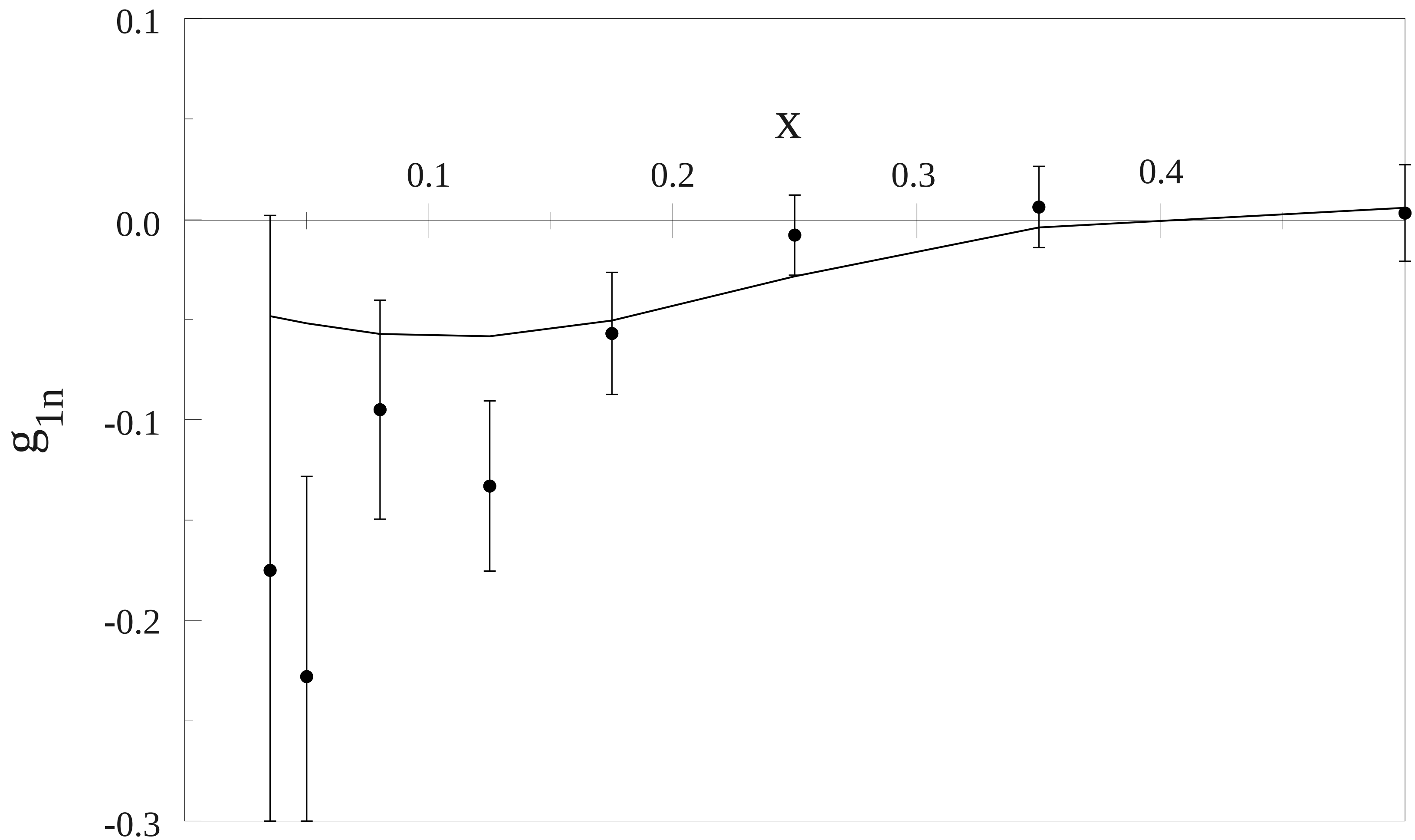

Fig.5 g_{1d} by SMC